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PROJECT VANGUARD REPORT NO. 14

PROGRESS THROUGH FEBRUARY 15, 1957

[UNCLASSIFIED TITLE] (8)

Project Vanguard Staff

343031

(11) March 12, 1957

NAVAL RESEARCH LABORATORY
Washington, D.C.

CONFIDENTIAL

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Project Vanguard Report No. 1, "Plans, Procedures, and Progress" by the Project Vanguard Staff, NRL Report 4700 (Secret), January 13, 1956

Project Vanguard Report No. 2, "Report of Progress" by the Project Vanguard Staff, NRL Report 4717 (Confidential), March 7, 1956

Project Vanguard Report No. 3, "Progress through March 15, 1956" by the Project Vanguard Staff, NRL Report 4728 (Confidential), March 29, 1956

Project Vanguard Report No. 4, "Progress through April 15, 1956" by the Project Vanguard Staff, NRL Report 4748 (Confidential), May 3, 1956

Project Vanguard Report No. 5,"Progress through May 15, 1956" by the Project Vanguard Staff, NRL Report 4767 (Confidential), June 2, 1956

Project Vanguard Report No. 6, "Progress through June 15, 1956" by the Project Vanguard Staff, NRL Report 4800 (Confidential), June 28, 1956

Project Vanguard Report No. 7, "Progress through July 15, 1956" by the Project Vanguard Staff, NRL Report 4815 (Confidential), July 27, 1956

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Project Vanguard Report No. 12, "Progress through December 15, 1956" by the Project Vanguard Staff, NRL Report 4890 (Confidential), January 16, 1956

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A general summary of progress on Project Vanguard discusses

CONTENTS

PREFACE

This report is intended as a general summary of the progress on Project Vanguard during the indicated period. Hence, minor phases of the work are not discussed to a great extent, and technical detail is kept at a minimum. It is hoped that the information here presented will be of assistance to administrative and liaison personnel in coordinating and planning their activities, and as a guide of the current status of the project. Material of a more technical nature will be published from time to time in separate reports which will be announced in subsequent monthly progress reports.

PROBLEM STATUS

This is an interim report; work on the problem is continuing.

AUTHORIZATION

NRL Problem A02-90

Manuscript submitted March 7, 1957

THE LAUNCHING VEHICLE

CONFIGURATION AND DESIGN

A preliminary study has been made to determine the extent to which the allowable ground wind velocity for TV-2 must be lowered due to the additional drag resulting from the vortex spoilers on the second stage.* Results indicate that the velocity reduction will be on the order of 2.6 knots, which is a minor penalty.

In connection with the problem of structural resonance (see page 5) an investigation has been made of the characteristics of the wind environment in order to specify more realistically the magnitude of wind shears and gusts. The wind shears which may be expected at the launch site can be determined from weather wind records taken at Patrick Air Force Base over the past years. The object of the investigation was to obtain information on the gust variations of wind velocity as a function of attitude.

A conference held at Langley Air Force Base with personnel from NACA yielded a method of estimating the gust velocities which may be encountered in a vertical flight. This method is presented in a publication† which defines the composition or structure of atmospheric turbulence in the form of a power density spectrum. Other information gathered by NACA presents the probability of encountering atmospheric turbulence at various altitudes with varying intensity. This information in combination with vehicle dynamics is being used to estimate the probability of encountering excessive vehicle bending stresses during the Vanguard flight. The results of this study will be employed to redefine the wind gust specification.

Instrumentation to measure the angle of attack is to be installed on TV's 2 - 5. The end organ will be a vane-type meter.

PROPULSION

First Stage

During this report period a total of 23 first-stage engine firings were made for the purposes of analysis of the current burnout problem‡ and analysis of new designs. In general, the results of the tests are as follows: (1) ceramic coating of the chamber walls does not appear to offer a satisfactory solution to the problem of chamber scoring and burnout, (2) the addition of copper cooling fins between the regular steel helices on the liquid side of the inner chamber wall has not yet been fully evaluated. The latter approach has not been successful in a full-duration firing, however, this is believed due to the fins being poorly spaced. Equi-spaced fins would yield better results, and a suitable test chamber with this configuration is expected shortly.

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*P.V.R. No. 13, p. 1
†Press, H., and Tukey, J. W., Bell Telephone System Monograph No. 2606, June 1956
‡P.V.R. No. 13, p. 2

In some of the tests reported above, thermocouples fastened to the liquid side of the inner chamber wall disclosed temperature cycling during the run: extreme temperature-rise rates indicate that some combustion anomalies are present, and this could be contributing to local high-temperature areas.

In view of the foregoing information, it is considered that the thermal capacity of the chamber should be increased so that complete curtain cooling at all times will not be mandatory. GE has completed an overall heat-transfer study and has submitted an improvement proposal outlining the use of a copper-tube chamber to meet this requirement.

Problems of flaking of the cadmium plating on the liquid side of the inner chamber wall have been eliminated by a new chemical plating material, nickel phosphide, which does not effect the heat-transfer characteristics of the plated metal.

The NACA has completed Phase I of the lox-fluorine test program. As has been described in previous reports,* this program was initiated to provide some further experimental verification of the combustion efficiencies of the 20-30% fluorine-lox-oxidizer mixture, burning RPI kerosene as a fuel. The three major fields of endeavor were as follows:

1. Twenty firings in a small chamber with RPI kerosene and lox were made for comparison purposes. An average characteristic exhaust velocity (C*) of 5380 fps was obtained; this is approximately equivalent to a specific impulse of 248 sec, and occurred at a mixture ratio of 2.22 with a maximum Q (unit area heat transfer from wall to coolant) of 1.1 btu/in.^{2}-sec. The chamber and injector suffered repeated burns and had to be patched.

2. Further runs were made with a modified injector; that is, jet impingements and the spray pattern were changed slightly to reduce wall burning. Water cooling instead of fuel cooling also maintained the integrity of the engine. Twenty-four calibration runs were obtained. The specific impulse was a little lower than above, because of the nonregenerative heat transfer. However, these runs served as adequate calibration for the later fluorine firings.

3. About a dozen runs were made with the fluorine-lox combination, still using water cooling. The average characteristic exhaust velocity was around 5600 fps with a Q of 1.4 btu/in.^{2}-sec at a mixture ratio of 2.5. The specific impulse (not a good criterion of performance in an experimental chamber) was about 10 seconds higher than that obtained in the water-cooled lox firings. The NACA substantiated, by these tests, their previous theoretical calculations of the lox-fluorine potential, which were based on partial data from North American Aviation, NACA, Bell Aircraft, and the Kellogg Corporation. There is no question that the X-405 chamber will show a substantial performance improvement if lox-flourine-kerosene can be burned in it. It is NACA's recommendation that JPX (a mixture of UDMH and kerosene) be used as the fuel.

Second Stage

The tank assembly for the second-stage prequalification propulsion unit has been completed and the unit is scheduled to be shipped to Sacramento on 19 February for the prequalification tests. The vehicle structural test tank is also complete and is being shipped to Glenn L. Martin. Seven other tank assemblies are in fabrication. The current schedule calls for six more tanks to be completed by about 1 March. The A. O. Smith Company has submitted two proposals in an effort to provide an alternate source of tank assemblies:

*P.V.R. No. 10, pp. 5-6, and No. 13, pp. 2-3
†P.V.R. No. 13, p. 3.

(1) to build three tank assemblies to the Aerojet design and (2) an A. O. Smith design employing a different method of joining the fuel and oxidizer tanks to the helium sphere, which obviates the necessity of heat treating the tank assembly as a whole. Arrangements have been made for A. O. Smith to proceed.

During this report period, welding was begun on the final thrust chamber. Several firings were made using white inhibited fuming nitric acid (WIFNA) to determine whether or not there was any change in performance or heat transfer between WFNA and WIFNA; no performance difference was noted.

Aerojet has completed four injectors of the Mod 34 pattern, which is an improvement over the Mod 28 (72-pair impinging jet) design in that 24 fuel holes have been added in the center of the injector face to improve local mixing. The Mod 34 injectors have given an approximate characteristic exhaust velocity of 5010 fps, with a chamber pressure of 206 psia and a mixture ratio of 2.75. The Mod 34 configuration has been adopted by Aerojet for prototype propulsion systems. There are three Mod 28 injectors which have passed Aerojet acceptance tests and these may be used in the first flyable propulsion units.

Third Stage

Allegany Ballistics Laboratory

During the last month, the Allegany Ballistics Laboratory experienced several third-stage case failures which were attributed to resonance burning or combustion instability; abnormally high pressure peaks were observed during burning. To solve this problem, a tripod-shaped resonance suppressor, embedded in the slotted portion of the propellant, was utilized. Heavy-walled steel chamber firings showed the tripod-shaped suppressor was adequate; however, burnouts continued when firing of the lightweight fiberglass chambers was resumed. ABL stopped further testing and made a complete analysis of the problem. The analysis showed the most likely causes of the failures were obturation or inadequate bonding of the insulator and propellant, inadequate sealing of the aft closure to the fiberglass case, and accelerated burning due to resonance. To verify these findings, it was decided to rupture a chamber during a static test. This was accomplished after 22 seconds of burning and inspection of the rocket revealed burning of the outside of the propellant in certain areas due to inadequate bonding and excessive erosion of the resonance suppressor. The current approach to the solution of these problems is: first, to fabricate the fiberglass case about a shell of phenolic asbestos as an integral part; second, to utilize a phenolic insulator instead of the silica-rubber; third, to case-bond the propellant by casting into the chamber directly rather than preparing a cellulose acetate beaker as the basting fixture; fourth, to mold the resonance suppressor in one piece; fifth to modify the aft closure slightly to incorporate an "O" ring and insure a more positive seal. If unforseen problems arise, an alternate approach is to incorporate a thin layer of cellulose acetate on the inner case surface over the phenolic asbestos layer, then utilize the case bonding technique. These procedures insure chemical bonds between all components.

Two rockets are to be tested prior to 5 March; then eight more firings will be made to prove out the design by incorporating temperature cycling tests, rough handling, and additional statistical firings.

Grand Central Rocket Company

The Grand Central Rocket Company is continuing prequalification testing. Eight tests have been made to date, of which six were made since the last report. The tests that have

been conducted include one temperature cycled rocket, a vacuum ignition, three statistical firings (for performance), and the vibration test at WSPG. Because of problems associated with ignition and the nozzle closure seal, delay was encountered in the prequalification test program. An ignition delay of 0.3 second has been experienced before nominal chamber pressure is reached, causing the closure to blow out prematurely. To decrease the ignition delay, the closure must be retained until the pressure increases sufficiently to sustain burning. The six remaining prequalification tests will be made after the closure problem is solved.

The results of the prequalification tests to date reveal reproducibility of rocket ballistics within 2.5 percent and no further problems associated with environmental testing. The Model Specification and the Inspection Procedure Manual are nearing completion and will be ready for use prior to the qualification test program.

Two inert GCR rockets are scheduled for shipment to AFMTC during the week of 18 February, and two live rockets will be sent approximately ten days after the closure problem is finalized.

There is no indicated change in the performance of the GCR rockets as previously reported.*

FLIGHT CONTROL

Guidance

Minneapolis-Honeywell has delivered two of the Vanguard three-axis reference systems and gyro calibration test equipment, and has submitted acceptable Model, Qualification, and Acceptance Test Specifications. The reference systems will be placed on test during the next month.

Attitude Control

Vickers, Inc., has delivered the first production unit of the magnetic amplifier; however, GLM's quality control department rejected this unit as unsatisfactory. The primary reasons for rejection were found early in the receiving inspection; therefore, the magnetic amplifier will not be thoroughly bench tested until a more satisfactory unit has been received. The Vickers Model, Qualification and Acceptance Test Specifications for the autopilot have been approved subject to certain changes.

Dynamic mockup tests have been run on the SLV post-cutoff pitch-yaw jet system. These tests indicated that proper lead was not introduced for large displacements. Saturation in the preamplifier which obscured the lead signal was found to be the cause of the difficulty. The preamplifier has been reworked to reduce its gain and thus prevent overloading, and the gain was restored in the servo amplifier. A breadboard unit employing this circuitry is being made, and additional dynamic mockup testing will be conducted near the end of February. Dynamic mockup tests of the first-stage roll jet system are being run at present.

The post-flight analysis of the TV-0 controls has been completed. It was determined that the roll jet controls operated properly but roll jet action failed to occur owing to malfunction of the jet valves or the controls peroxide system. The post-cutoff jet controls also operated properly, but again jet action did not occur. The roll tabs in TV-0 reversed direction during part of the flight, apparently because of some malfunction in the SW tab

*P.V.R. No. 12, p. 7

servo loop. The TV-0 flight azimuth error of 4.5 degrees may be accounted for by an accumulation of errors in alignment: the vehicle on the launch pad, the resolver in the vehicle, and the gyro mounting in the vehicle. Analysis of the vehicle azimuth is continuing. The action of the inversion gyro control was not observed owing to the loss of attitude control after burnout.

The problem of structural resonance previously reported* has undergone intensive investigation and the present conclusion is that the design configuration of all vehicles is adequate. However, analysis of the problem is continuing. In the analysis of the effect of the elastic bending of the vehicle, the first concern was that the mechanical feedback of these oscillations to the reference gyro, in combination with the dynamics of the forward autopilot loop, must provide a stable closed-loop system. Stability was obtained theoretically by the insertion in the autopilot of a rejection filter centered at the second mode of structural resonance along with a lag circuit effective at the first mode of structural resonance. Induced oscillation in the gimballed engine along with the transverse oscillations of the vehicle structure were underdamped, as would be expected from Vanguard's high fineness ratio and low bending stiffness. In addition, the compatibility of the aerodynamic structure had been established by hand computation for flight with an angle of attack of 5.5 degrees at maximum dynamic pressure and with an engine deflection of 4.5 degrees. The bending induced in the structure for this steady-state condition was approximately 70 percent of that allowable. Wind gust loading equivalent to flying into a 40-fps stratum was superimposed on this steady-state loading and it was determined that the dynamic bending moment which resulted was equal to the remaining 30 percent margin. It was concluded that the vehicle could fly in the presence of the specified wind profile and superimposed gusts, since the steady-state engine deflection associated with the maximum wind profile velocity is approximately 2 degrees.

In late December, 1956 a vibration resonance study disclosed that a sustained sinusoidal oscillation with a driving force of 3 to 4 pounds could provide sufficient excitation to destroy the vehicle. A corresponding inertial force is developed by the engine for very small deflections when oscillating at the first mode frequency of the structure. The effect of a thrusting engine was examined and it was determined that the lateral thrust component exceeded the engine inertial force by a factor of 10. In the Viking, the magnitudes of these forces were approximately equal and, since their effects on the structure were opposed, large deflections of the engine were allowable. The above studies were based on hand computations and it is recognized that many simplifications and approximations had been made.

Vehicle production was frozen in mid-January while the following courses of action were pursued: (1) TV-2 was installed in the vertical test fixture for shake tests; (2) structural changes for light and heavy "beef-up" were determined; (3) a refined REAC study was instituted; and (4) the wind-gust specification was re-examined. The shake tests on TV-2 confirmed the theoretical estimates of structural damping. Modal deflections were obtained, and in combination with wind-tunnel pressure distribution data, a digital computer was used to obtain forcing functions for the refined REAC study, at eight vehicle stations for various sharp-edged gust and wind gradients. Preliminary results of the refined REAC study indicate that the phase of the engine response in relation to the angular bending seen at the gyro introduces a large damping factor to provide a stable system in the presence of the specified wind gust. Gust bending is approximately 50 percent of that allowable. As a result, no structural modifications of the vehicles are contemplated and production has resumed. Analysis of the REAC data is now in process and more complete information will be available shortly.

*P.V.R. No. 11, p. 7, and No. 13, p. 5

Flight Program and Staging

Aerojet has conducted three firings to determine the effects of second-stage flame impingment on the first-stage lox tank dome during separation. One test was made with an insulation blanket covering the lox dome and no transition skirt joining the first and second stages; the insulating blanket was disintegrated. Another test omitted the blanket but the transition skirt joined the first and second stages; the transition section was burned through and the lox tank was ruptured. The third test employed neither the transition section nor the blanket and no damage resulted. These results are being studied to determine what danger exists, if any, of damage to the second stage as a result of the rupture of the first-stage lox dome.

The thermal batteries for firing the third stage (TV-1) have undergone environmental tests successfully.

Modification of one centrifugal switch to accommodate a third-stage spin rate of 128 rpm has been initiated. This action was taken to prevent delay in the event that it is necessary to increase the spin rate in order to provide the necessary stability for the third stage in flight. Circuitry involving some additional relays is being developed to fire the "Daisy" flares which will be installed in TV's 3 - 5 as an aid to optical tracking. The installation on TV-3 and backup will consist of twenty flares to be ignited in groups of five at the following times: (1) first-stage burnout, (2) second-stage burnout, (3) prior to third-stage ignition, and (4) following third-stage powered flight. The time interval between flares will be controlled by a powder delay train and will be compatible with the resolution required by the ground-based optical tracking installations. TV's 4 and 5 will be similar except that no flares will be installed on their third stages.

The Atlantic Research Corporation has completed their initial qualification test program on the spin and retro rockets. Because of changes in the method of sealing the igniter, eight additional vacuum firings were performed. These firing data indicate satisfactory ignition in vacuo. The aerodynamic cone for protecting the retro rockets from aerodynamic heating has been completed.

THE SATELLITE

CONFIGURATION AND DESIGN

20-Inch Satellite

The polishing and plating procedure for the 20-inch satellites at Brooks and Perkins has evidently proven very successful. Briefly, the plating consists of layers of zinc, copper, silver, and gold, in that order. The final treatment will add coatings of chromium, silicon monoxide, aluminum, and silicon monoxide again; this will be done at ERDL, Fort Belvoir, Virginia.

Units 5 and 6 have been received from Brooks and Perkins, and the finish and plating were found to be very satisfactory. The weight added by the plating materials has been somewhat compensated for by reducing the thickness of the shell in areas of low stress through a technique developed by Brooks and Perkins for machining the shell after welding. The pressure zones still have minute leaks which cannot be detected by hydrostatic tests, but a method is now under development for sealing these leaks. The fabrication difficulties have been overcome and at present one unit per week is scheduled for delivery.

Units 3 and 5 have been successfully given the final silicon monoxide coating at ERDL; the visible reflectance is in the order of 80-82 percent on each unit; since the highest value attainable for the present surface would be about 85 percent, the results are very satisfactory. Emissivity studies on the internal can are still in progress; the emissivity of the can generally is in the order of 0.04, which is acceptable, the lowest figure attainable being about 0.02.

Unit 1 has undergone steady-state accelerations up to 55 g without failure, and further testing, up to 70 g, is scheduled. Destructive vibration tests have also been made on this unit; a systematic increase of acceleration levels through the frequency range from 10 to 2000 cps ended in failure at 20 g and 44 cps, which is well over the maximum expected vibration level. The fractured components are shown in Fig. 1. The base mounting hub on the internal package fatigued as a result of the many reversals of stress at high acceleration levels. The Kel-F side support fractured simultaneously, as did one of the antennas. The internal can contained 10.25 lb of lead-filled modules to simulate the current weight of the electronics during all tests. At 20 g and 44 cps, this loading would produce a 205-pound force which would act up and down at the rate of 44 times per second.

The main base Kel-F support is being reduced in cross section to reduce its thermal conduction. A step-by-step reduction and load test program is underway to give minimum cross section with known load-carrying characteristics.

The remaining 18 satellite separation mechanisms are scheduled for delivery on 1 March 1957; indications are this date will be met.

Fig. 1 - Fractured 20-inch satellite components after failure at 20 g and 44 cps; arrows indicate points of failure

An improved heat switch has been designed for the 20-inch satellite, to meet the following requirements associated with the new internal package:

Thermal conduction: 60 mw/°C

Can-temperature switch point: 25°C ±5°C

Shell-temperature switch point: 50°C ±3°C

Manufacturing drawings for a prototype are being made and a testing procedure is being devised. It is still not certain that the heat switch will be required in all of the 20-inch satellites.

A breakdown of the current weights for the NRL 20-inch environmental satellite is given in Table 1.

The design of the 20-inch satellite for the State University of Iowa's cosmic ray experiment is underway. The shell, structure, and antennas are similar to the NRL environmental satellites, except for (1) the internal package design, (2) a heat shield around the internal package, and (3) the omission of pressure zones. An aluminum prototype of the SUI satellite is now completed. Preliminary vibration tests on the shell have been completed and further tests are scheduled for 18 February.

6.44-Inch Satellite

Units 5 through 8 of the twenty 6.44-inch satellites now on order are due for delivery on 18 February. All Kel-F supports and heat switches for these and the remaining units have been completed.

Fig. 1 - Fractured 20-inch satellite components after failure at 20 g and 44 cps; arrows indicate points of failure

An improved heat switch has been designed for the 20-inch satellite, to meet the following requirements associated with the new internal package:

Thermal conduction: 60 mw/^{0}C

Can-temperature switch point: 25°C $\pm$5°C

Shell-temperature switch point: 50°C $\pm$3°C

Manufacturing drawings for a prototype are being made and a testing procedure is being devised. It is still not certain that the heat switch will be required in all of the 20-inch satellites.

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6.44-Inch Satellite

Units 5 through 8 of the twenty 6.44-inch satellites now on order are due for delivery on 18 February. All Kel-F supports and heat switches for these and the remaining units have been completed.

TABLE 1
Breakdown of Current Estimated Weights
for NRL Environmental Satellite

Components	Current Weight (lb)
MINITRACK SYSTEM	
Antennas	0.68
Batteries	6.78
Electronics	0.30
Plastic Foam	0.53
Total	8.29
LYMAN-ALPHA EXPERIMENT	
Electronics & Detectors	0.44
Batteries	0.25
Skin Attachments	0.13
Wiring & Plastic Foam	0.11
Total	0.93
TELEMETERING SYSTEM	
Coding System	0.19
Orbital Peak Memory Unit	0.19
Plastic Foam	0.33
Interconnecting Leads	0.19
Batteries	0.43
Total	1.33
ENVIRONMENTAL EXPERIMENTS	
Pressure Zones	1.76
Pressure Gage & Connections	0.21
Pressure Set Valve	0.03
Erosion Test Device	0.10
Meteor Counter & Amplifier	0.31
Four Microphones	0.25
Total	2.66
STRUCTURE	
Internal Frame	1.23
Internal Package and Supports	1.25
Shell	3.08
Total	5.56
SEPARATION MECHANISM	0.98
DYNAMIC BALANCING	0.20
MISCELLANEOUS	1.00
COMPLETE SATELLITE	20.95

A test has been made on unit 4 to determine the amount of vibration transmitted to the internal electronics for three different means of attachment; (1) unit on separation mechanism dry (actual flight situation), (2) unit on separation mechanism with grease, and (3) unit rigidly attached to table, no separation mechanism. Vibration runs were made in three mutually perpendicular directions, and the highest transmission occurred with the rigid attachment; the lowest transmission occurred with the dry separation mechanism.

INSTRUMENTATION

A preliminary systems check has been run on the instrumentation in a completely assembled NRL environmental satellite. The Lyman-alpha ion chamber was excited from an external source to simulate a solar flare, and resistances were varied in the various time channels to produce the effect of surface erosion and temperature change. The results were satisfactory. In future tests the antenna will be bypassed, and the transmitter will feed directly into the telemetry receiver through a calibrated attenuator.

Some interference was experienced with the amplifier of the meteor collision detector when it was assembled into the satellite telemetering package. Investigation revealed that the interference had two sources: the gating pulses fed to the magnetic event counter, and rectification of the modulated 108-Mc signal in the first stage of the amplifier. Relocation of signal leads and proper filtering appears to have eliminated the interference.

The first magnetic tape recorder (FR 100) for ground recording of satellite telemetry signals has been received, and the acceptance test has been completed. Two Waterman Panelscope monitors have been received and subjected to performance tests. Present efforts are being directed toward the integration of a complete prototype telemetry receiving and recording system. One element of the system, a control console, is being designed to provide a centralized control of all signals to be recorded.

In the SCEL program for development of a solar power supply for application to project Vanguard, fifteen solar power supplies have been fabricated and delivered to NRL for testing in Aerobee-Hi rockets.

Design, fabrication, and installation of the camera extension sections of two Aerobee-Hi rockets, to carry the NRL environmental satellite instruments in the forthcoming tests at WSPG, is complete; the structural tests will be completed shortly.

ELECTRONIC INSTRUMENTATION

TELEMETERING

PPM/AM Systems

The ppm/am telemetering transmitters for TV-3 and backup have been delivered to GLM. Four more transmitters are undergoing final tests by the contractor and are scheduled for delivery to NRL on 4 March; the delay on these units has been due to defects which the Spivey Co. discovered in their stock of 6AQ6 tubes. Two to four more transmitters and five rf transmitting heads are scheduled for delivery on 11 March.

The ppm/am calibrators for TV-3 and backup have been delivered to GLM. Eight additional calibrators have been received at NRL, and six of these have been tested and accepted; testing of the remaining two is underway.

The Wilkes Precision Instrument Company has delivered twelve video recorder film magazines and thirty tape reels. Testing to date indicates that four of the magazines and thirteen reels are unacceptable.

PWM/FM Systems

The new pwm/fm telemetering transmitter package,* incorporating a transistorized power supply, has been completed and is undergoing environmental tests. If the unit is entirely acceptable, it will be flown in TV-4. Revised bench checks of the pwm/fm telemetry systems have been forwarded to the Vanguard Operations Group at AFMTC.

FM/FM Systems

The AN/UKR-5 fm/fm and pwm/fm ground station,† with associated test equipment such as the Heiland recorder, has been set up in hangar C at AFMTC and is being used for transmitter checkout and calibration.

The blockhouse fm/fm monitor rack, incorporating receiver, panoramic indicator, and calibration, has been checked out through the rocket wiring in the hangar.

VEHICLE TRACKING

The construction of a C-band AN/DPN-48 radar beacon at Melpar is now nearly complete. However, testing and delivery of this unit are contingent on the acquisition of a suitable C-band magnetron.

RANGE SAFETY

A contract has been let with the Connecticut Telephone and Electric Company for production of the KY-55/ARW transistorized vehicle command signal decoder.

*P.V.R. No. 13, p. 13
†P.V.R. No. 8, p. 13

THE MINITRACK SYSTEM

During January, 1957 the contracts for on-site construction work at the American stations of the Army Prime-Minitrack station network were awarded under the supervision of the District Engineer, U. S. Army Engineer District, Jacksonville. The on-site construction work for the Fort Stewart station was advertised for bid on 29 January by the District Engineer, U. S. Army Engineer District, Savannah, and bids will be opened 26 February 1957.

Shipments of government furnished materials to the Latin American stations are now in process. Astronomic position and azimuth observations have been completed at all sites except Antofagasta, Chile. A first-order geodetic tie was made to the center of the Havana site and work was initiated on first-order geodetic connections at Cotopaxi and Antofagasta. Signal Corps commissioned and enlisted personnel have been assigned to the Army Map Service for command and operation of the stations and the Vanguard Project Office has been established at the Army Map Service* with Engineer and Signal commissioned personnel assigned. This office will coordinate training and the establishment and operation of communications, telemetering, and tracking, for the six Army Prime Minitrack stations.

An inspection party is presently enroute to South America to inspect each Prime Minitrack site with the site contractor. This is necessary at this time to coordinate the operations of the contractor and NRL with respect to the rf cable installations, the antenna mount installations, the antenna assembly, and the equipment arrivals.

Contract operations have been in process at Mayaguana, Grand Turk, and Antigua for several weeks. Cable installation will begin at these locations in that order about 1 March; work with cable splicing and installation teams on site will be supplied by the Laboratory.

Station establishment procedures at all stations are being put on the following approximate schedule, where S is the date of the first expected satellite vehicle launching:

S - 14 weeks: Phase I – Start antenna assembly on rails already prepared by site contractor, lay rf cable in ditches and cover ditches, and install calibration and camera shelter. Site team to consist of 4 mechanics and 2 engineers from NRL.

S - 9 weeks: Complete Phase I. Start Phase II – Antenna survey and alignment. Site team to consist of one civil engineer and one technician from NRL.

S - 7-$\frac{1}{2}$ weeks: Complete Phase II. Start Phase III – Equipment arrival. Install Minitrack electronic trailer in place on pad at site prepared by site contractor, unload all equipment, connect all components of Minitrack and telemetering systems. Site team to consist of permanent operating crew of one U. S. Army Officer, approximately twelve Army enlisted personnel, two contract engineers, and one NRL scientist as Station Technical Director.

*P.V.R. No. 12, p. 1

S - 6 weeks: Complete Phase III. Start Phase IV – Station alignment and adjustment, wherein all components of the Minitrack equipment are critically aligned and adjusted and station electronics are put in final operating condition. Site team to consist of three NRL scientists and the permanent operating crew.

S - 4-$\frac{1}{2}$ weeks: Complete Phase IV. Start Phase V – Calibration. Calibration airplane and calibration crew arrive to align calibration camera, install, align and adjust the calibration electronic units and perform complete calibration of entire Minitrack station components using high-flying aircraft with flashing light against star background. Site team to consist of two NRL scientists and the permanent field crew.

S - 2-$\frac{1}{2}$ weeks: Phase V completed. The station is now assumed to be ready for satellite tracking and requires only continued operation and daily solar and radio star checks to monitor its operation.

The Minitrack System Training Class is about to begin, with the initial class scheduled for 4 March. Six classes, each of five weeks duration, are presently scheduled with class starting dates of 4 March, 25 March, 15 April, 6 May, 27 May, and 10 June. The first three weeks will take place at NRL, using duplicates of actual Minitrack system components in special training units prepared for this purpose. The last two weeks will take place at the Blossom Point Minitrack Test Facility, with one or two days spent at the Minitrack Ground Station Unit contractor's Plant (the Bendix Radio Division, Bendix Aviation Corporation, Towson, Maryland). All classes are being established with about 12 men each, as follows:

Class 1: 6 U.S. Army officers
4 U.S. Army technical representatives
2 NRL personnel

Class 2: 6 NRL personnel
6 unassigned

Class 3: 3 U.S Army Map Service personnel
5 U.S. Army enlisted crew for Santiago, Chile station
5 U.S. Army enlisted crew for Antofagasta, Chile Station

Class 4: 3 U.S. Army Map Service personnel
5 U.S. Army enlisted crew for Lima, Peru station
5 U.S. Army enlisted crew for Quito, Ecuador station

Class 5: 3 Australian personnel
5 U.S. Army enlisted crew for Havana, Cuba station
5 U.S. Army enlisted crew for Fort Stewart, Georgia station

Class 6: 6 NRL personnel
6 Navy Electronics Laboratory personnel

DATA PROCESSING

TELEMETERED DATA

Reduction of the nose-cone telemetered data (ppm/am) from the TV-0 flight has been delayed; however, the Physical Science Laboratory of the New Mexico College of Agriculture and Mechanic Arts expects to forward preliminary results about the end of February 1957. NRL has now received the pwm/fm data reduced by AFMTC, and the ppm/am and pwm/fm data reduced by GLM from the vehicle telemetering records for TV-0.

The data recording trailer of the automatic recording and reduction facility (ARRF)* being built by Radiation, Inc. may be sufficiently near completion by the time of the TV-1 launching to permit digital recording of the ppm/am data at the NRL Telemetry Pad (Cape Canaveral) for this flight. The pwm/fm and fm/fm portions of the data recording system should be completed in time for the flight firing of TV-2. Although the interim transistorized ppm/am quantizer developed at NRL was ready in February as planned, it has been decided not to deliver the unit to Radiation, Inc. until it is needed, so that further circuit improvements can be made. A translator for the pwm/fm ground station has been modified at NRL so that its output can be used for encoding and recording by ARRF of all 45 channels of pwm/fm data in real time. This translator has been checked by Radiation, Inc. and appears satisfactory.

The linearizer for the digital data reduction system of the ARRF is being built for Radiation Inc. by RCA. This linearizer, a matrix of magnetic cores with transistor drivers, is a digital function table which will serve to eliminate nonlinearities in the telemetered data as recorded. A simulator has been built for checking the operation of the subchannel selector being developed at NRL for the data reduction portion of the ARRF. Work on noise rejection circuits is continuing.

ORBITAL DATA

The final drawings and rendering of the front of the Vanguard Computing Center as submitted by the International Business Machines Corporation for the building at 615 Pennsylvania Avenue, N. W., Washington, D. C., have been approved by the D. C. Commission of Fine Arts. The interior demolition work is nearly completed in preparation for complete remodeling inside the building. The building contractor will complete his work in May and the center will be ready for operation with the IBM 704 computer in June 1957.

Programming for and test computations on the 704 computer have been continued by the IBM mathematicians for elliptic orbit determination and prediction from sets of three and four observations.

THIRD-STAGE FIRING PREDICTION

The Milgo Electronic Corporation submitted the only bid to provide the equipment for transmitting the digital output of the IBM 704 computer at Cape Canaveral to the third-stage firing control console at Central Control. It is expected that this contract will be let by the RCA Service Company at AFMTC by the end of February 1957 and that the equipment will be delivered 120 days later.

*P.V.R. No. 11, p. 26

RANGE OPERATIONS

The controls functional checks on TV-1 in hangar C have been completed. The inversion and separation checks encountered some difficulties and are not yet complete; however, completion is expected very shortly. Calibration of the controls functions end organs is complete, and the remaining instrumentation checks must await the arrival of the nose cone.

Delivery of the nose cone is being delayed because of problems of dynamic balancing, antenna testing, and instrument installation; although the additional delay is not expected to be great, no firm delivery date can be given at this time.

The telemetry ground stations are checked out and ready for the TV-1 launching; however, attempts to improve their operation will continue. Some work on the vehicle fm/fm transmitter has been necessary to eliminate noise; this work is progressing satisfactorily. The two ppm/am transmitters and the spare pwm/fm transmitter have been checked out and are satisfactory; the flight pwm/fm transmitter is expected to arrive with the nose cone. Two sets of command receivers have also been tested satisfactorily. Preparations are underway to test the AN/DPN-19 radar beacon in an airplane flight, and a blockhouse panel to monitor the operation of this beacon is under construction.

If the nose cone is not delayed more than is now expected, TV-1 will be launched on or about 10 April.

* * *

CONFIDENTIAL

Naval Research Laboratory. Report 4910 (CONF.)
PROJECT VANGUARD REPORT NO. 14 - PROGRESS THROUGH FEBRUARY 15, 1957 (Unclassified Title), by Project Vanguard Staff, 15 pp. and figs., March 12, 1957.

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